Technical Report 1

Existing Lighting Conditions and Design Criteria

Smeal College of Business Building

University Park, PA

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Lighting/Electrical Option
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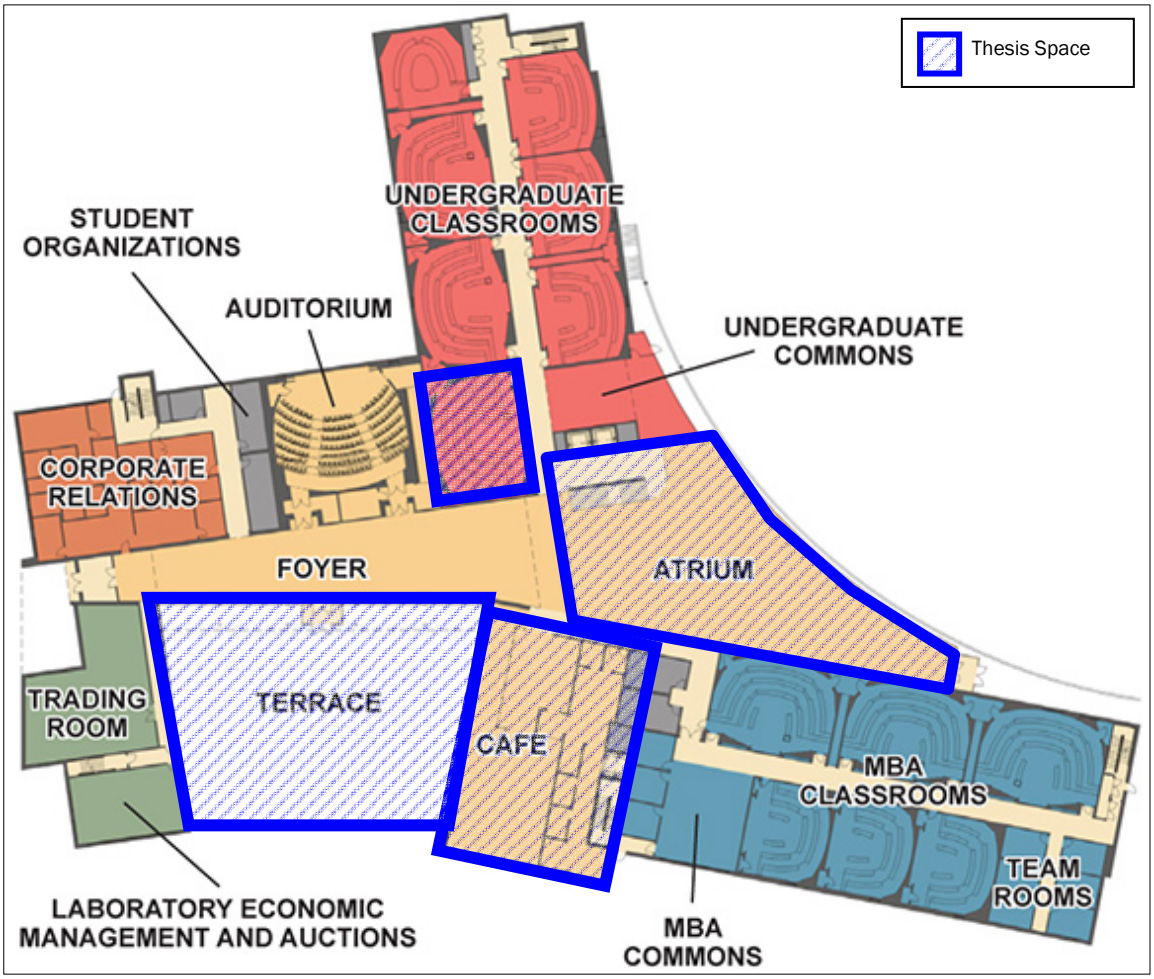
TABLE OF CONTENTS

BUILDING OVERVIEW

At 210,000 ft², the Smeal College of Business Building is currently the largest academic building at the Pennsylvania State Univeristy. More commonly referred to on campus as simply the Business Building, it is a research and educational facility designed to bring the Pennsylvania State University's undergraduate and graduate business programs together under one roof.

The building is comprised of two wings connected by a foyer and an atrium. The north wing is the larger of the two and is dedicated to the undergraduate program, while the smaller wing to the building's south is dedicated to the MBA program and also contains the Blue Chip Bistro Café. In addition to the usual spaces that are typical of a post-secondary education building such as classrooms and offices, some notable spaces include video-conferencing



Source: www.smeal.psu.edu/building/floor (plan image)

Figure 0.1 – Basic plan view of first floor with thesis spaces highlighted in blue.

facilities, interview rooms, study rooms, various research laboratories, common areas for each of the two degree programs, an auditorium, and a mock trading room.

This report will analyze the current lighting conditions of the atrium, a typical classroom, the café (which includes the servery, coffee bar, and dining area), and the terrace.

GENERAL ASSUMPTIONS

Any equipment data that was not provided by the drawings or specifications was assumed for the calculation purposes of this report by referencing the respective information from a different but equivalent product. For example, all ballast factors were taken from equivalent Advance Transformer ballasts if those of the specified ballasts were not readily available. Other assumptions include a "Very Clean" environment and a 24-month cleaning cycle, which were used to calculate light loss factors.

Computer models and other supplemental files that are referenced in this report can be found at www.engr.psu.edu/ae/thesis/portfolios/2009/YXH150/tech-assign.htm.

ATRIUM

DESIGN CRITERIA

A grouping of sofas, tables, and table lamps encourages students to use the atrium as a gathering and study space as well as for circulation, giving the atrium a lobby or lounge-like atmosphere. The IESNA Lighting Handbook recommendations for office lobbies, lounges, and reception areas are 5 fc horizontal illuminance and 3 fc vertical illuminance.

Other IESNA design issues that will be important to keep in mind for this space are *Appearance of Space and Luminaires*, *Direct Glare*, *Point(s) of Interest*, and *Sparkle/Desirable Reflected Highlights*. These issues are particularly important because of the visibility of the atrium not only from the interior but from the exterior as well; the entire north-facing wall of the atrium is a glass curtain wall making the space fully and clearly visible from the outside at night. A west-facing clerestory at the walkway, and a skylight above the central staircase in addition to the glass curtain wall allows much daylight into the atrium meaning *Daylighting Integration and Control* should also be considered to ensure an adequate but comfortable lighting design that is also energy conscience. However, despite these additional uses the atrium's primary function is to serve as the building's central circulation space so a lighting design that is most appropriate for egress should take precedence above all else.

SPACE PROPERTIES

GENERAL

ITEM	MATERIAL/FINISH	ρ / τ
Floor	Vinyl Tile, tan	0.35
Ceiling	Painted GWB, white	0.85
Walls	Wood, natural maple Aluminum	0.48 0.57
Glazing*	*See below for more information.*	0.70

**Includes curtain walls, interior windows, stair guardrails, and etched glass wall.*

Table 1.1 – General Atrium Space Surface Reflectances

FURNITURE AND OTHER ELEMENTS

ITEM	MATERIAL/FINISH	ρ
Seating		
Sofas	Fabric, multicolors	0.25
Chairs	Plastic, blue	0.25
Tables		
Round Tables	Wood	0.75
End Tables	Plastic, white	0.80
Table Lamps*		
Body/Base	Metal	0.60
Shade	Plastic, orange	0.55
Kiosk	Metal	0.44

**Table lamps were treated as furniture elements and not as luminaires; potential light contributions were not considered for this report as they are not part of the official lighting design.*

Table 1.2 – Atrium: Furniture Reflectances

GLAZING

The performance characteristics for all glazing are based on Viracon's VE1-2m product and were specified as follows:

U-Value	Shading Coefficient	SHGC[a]	τ[b]
0.29	0.43	0.37	0.70

[a] *Solar Heat Gain Coefficient*
[b] *Visual Transmittance*

Table 1.3 – Typical Glazing Properites

- **Type IN:** nominal 1" thick insulated vision sealed unit
  - Minimum ¼" clear exterior lite, low emissive coating on surface #2 heat strengthened or tempered where required by code
  - ½" air space
  - ¼" clear interior lite, tempered per code

- **Type SP:** Type IN for spandrel applications
  - Minimum ¼" clear exterior lite, low emissive coating on surface #2 heat strengthened or tempered where required by code
  - ½" air space
  - ¼" clear interior lite, heat strengthened tempered as by code
- **Type SG:** nominal 1⅛" thick insulated vision sealed unit
  - Minimum ¼" clear exterior lite, low emissive coating on surface #2, tempered
  - ¼" air space
  - Minimum ⅜" laminated, heat-strengthened, clear, interior lite, consisting of minimum 3/16" clear glass, 0.060" PVB interlayer, minimum 3/16" clear lite

LIGHTING DESIGN

PLANS

See Table 1.7 for the atrium luminaire schedule.

Figure 1.4 – Atrium Lighting Plan And Furniture Layout, First Floor

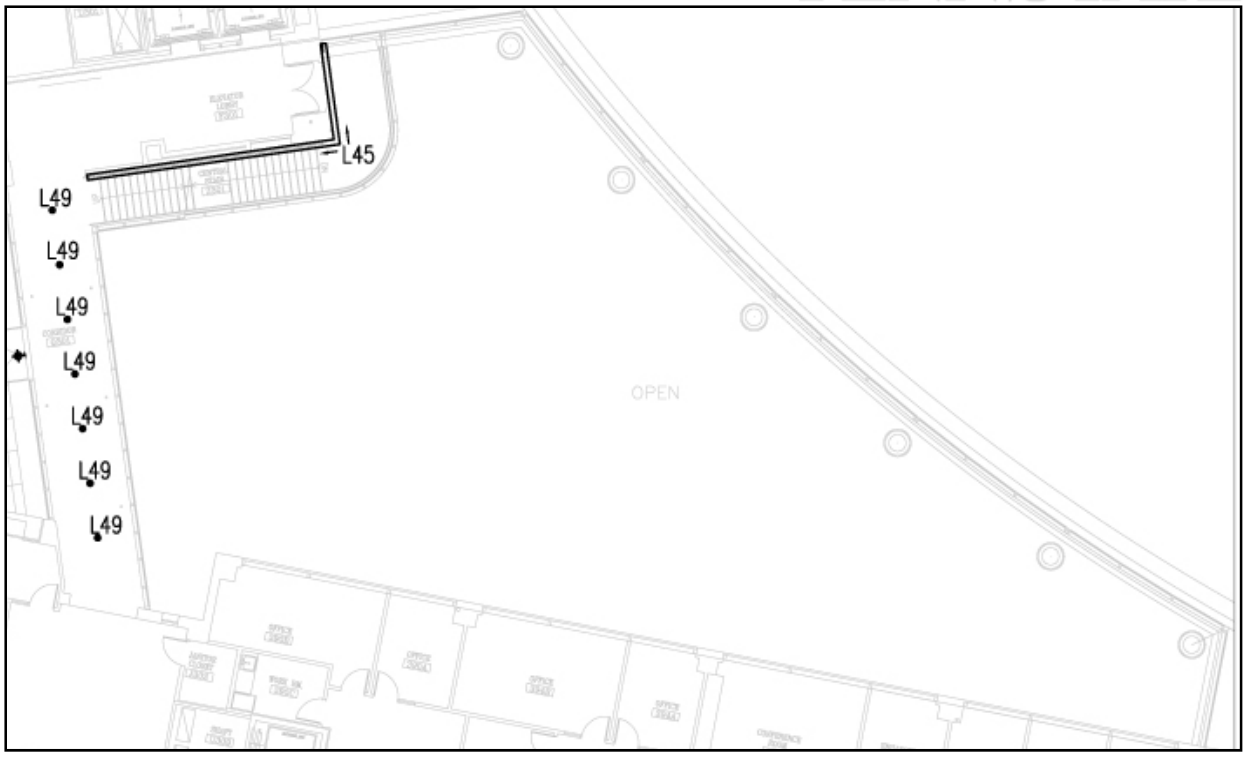


Figure 1.5 – Atrium Lighting Plan, Second and Third Floors

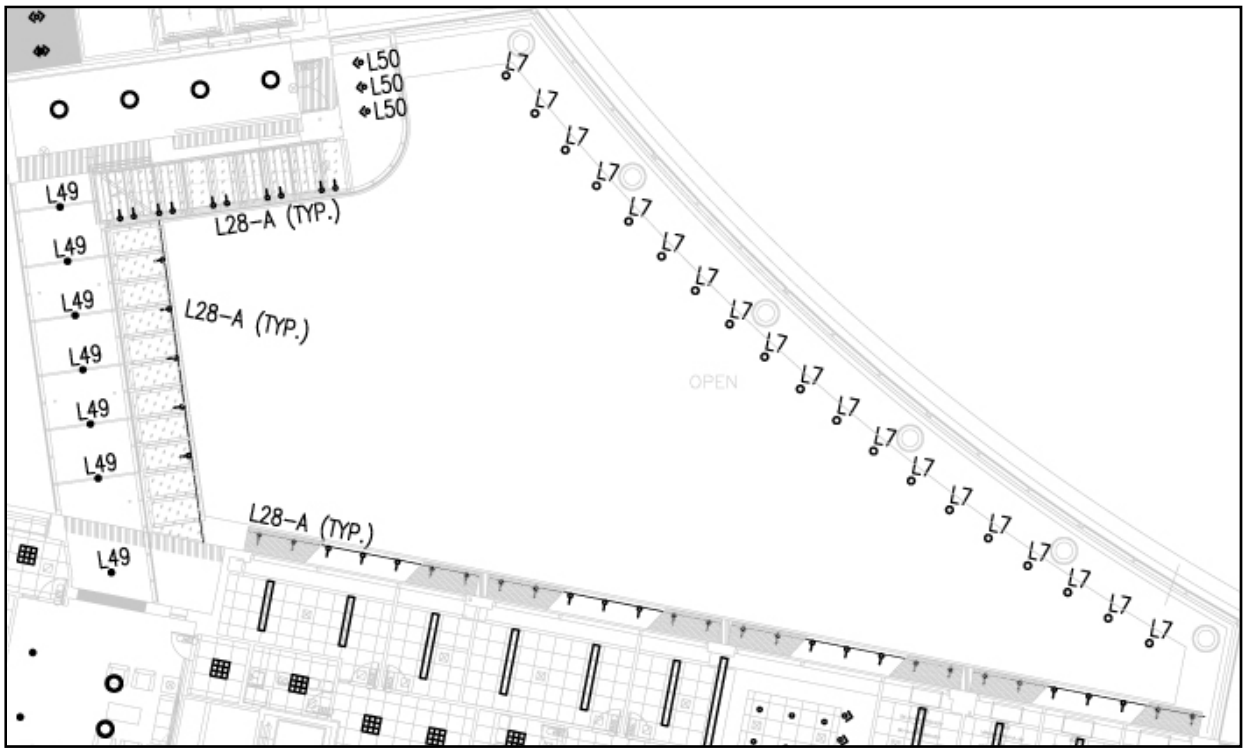
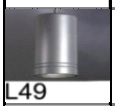


Figure 1.6 – Atrium Lighting Plan, Fourth Floor

HARDWARE

TYPE	DESCRIPTION	MFR/CATALOG#	LAMP	LOCATION
 L4	Recessed compact fluorescent open downlight with 6" dia. aperture and integral electronic ballast.	Prescolite CFCB832THEB-STC6B8ACL (White Finish on Blades and cone)*GD	Philips PL-T 32W/830/4P/ALTO	Bridge
 L6	Recessed compact fluorescent open wall wash downlight with 6" dia. aperture and integral electronic ballast.	Prescolite CFT632HEB-STF602W-Trim Finish*GD	Philips PL-T 32W/830/4P/ALTO	Wall by café
 L7	Recessed conoid aperture adjustable accent light w/ Soft Glow cone, white flange trim, integral elec. ballast, holder for 360° lamp assembly rotation and 45° tilt.	Kurt Versen R7410-SC-WT-EBH100W-277V-FF38-2	Philips 'Master Color' CDM100/PAR38/SP/3K	Curved glazed wall
 L28-A	Track mounted wallwasher w/ alum. housing. Steel self-locking yoke w/ on/off switch; spread lens, black louver, and beam softener.	LSI, Cat# 2907.00 Accessories: Louver C, Hood C, Spread Lens C996 (45x50deg)	Philips 'Master Color' CDM70/PAR38/FL/3K	MBA wall, bridge, stair tower
L29	Wall mounted continuous fixture at 4' increments on 12" suspended arm. Integral ballast, rectangular canopy, brushed nickel finish.	Translite Sonoma #SL5-1-54-IN-12"-NK	Osram Sylvania FP54/830/HO/ECO	Glass wall
L45	Surface mounted in recessed architectural pocket; consists of cold cathode tubing mounted into continuous finished metal enclosure with butt glazed opal glass lens in 7" aperture.	National Cathode Corporation SS24-240MA NPF Custom enclosure; remote transformer in wall under Elevator lobby benches	Cold Cathode Double Row 240MA system to produce 1550 lm/ft	Stair tower
 L49	Pendant mounted cross baffle cylinder. Die cast construction w/ integral electronic ballast.	Gardco #300-DP-LL-32TRF-277-Finish	Philips PL-T 32W/830/4P/ALTO	Bridge @3rd & 4th floors
 L50	Recessed 5-7/8" conoid aperture wall-washer in architectural slot w/ integral dimming ballast.	Kurt Versen P915-SC Lutron HiLume 1% dimming ballast	Philips PL-T 42W/830/4P/ALTO	Stair tower @4th Floor

NOTE: All fixture volts are 277 V, except Type L50 (120 V).

Table 1.7 – Atrium Luminaire Schedule

All non-decorative lighting was hidden as much as possible by limiting fixtures to the perimeter of the atrium. PAR38 metal halide downlights punch light along the curved curtain wall and track-mounted adjustable wall-washers of the same lamping light the other walls while tucked into an architectural slot along the perimeter. Compact fluorescent downlights light areas of the atrium that are not open to all four levels (e.g., the suspended bridge), and a linear cold cathode fixture in a custom aluminum enclosure highlights and illuminates the central staircase. In addition to the custom cold cathode fixture, other decorative fixtures include a slim, continuous, wall-mounted linear fluorescent wall-washer above a clear

etched-glass donor wall, and individually switchable incandescent table lamps that complement the furniture in the lounging area.

SYSTEM PERFORMANCE

POWER DENSITY

DESIGN

Type	QTY	Wattage	Total [W]
L4	20	37 W	740
L6	12	37 W	440
L7	18	100 W	1,800
L28-A	33	70 W	2,310
L29	22	62 W	1,364
L45	133 ft	37 W/ft	4,921
L49	15	35 W	525
L50	3	49 W	147
		Total Power	**12,250 W**
		Area	**12,180 ft^2**
		Power Density	**1.01 W/ft^2**

Table 1.8 – Atrium Lighting Power Density

ASHRAE/IESNA 90.1

USE	LPD [W/ft^2]
Atrium – First Three Floors[a]	0.6
Atrium – Each Additional Floor[a]	0.2
Additional Interior Lighting Power[b]	1.0
TOTAL	**1.8 W/ft^2**

[a] *Table 9.5.1: Lighting Power Densities Using the Space-by-Space Method*

[b] Per *article 9.6.3 (a) for accent lighting (Type L29).*

Table 1.9 – Power Allowance for Atriums

COMPLIANCE CHECK

1.01 W/ft^2 ≤ 1.80 W/ft^2 ✔

LIGHT LOSS FACTORS

Type	Lamp	LLD	Maint. Cat.	LDD	BF	TOTAL LLF
L4	CFL	0.85	IV	0.89	0.98	**0.741**
L6	CFL	0.85	IV	0.89	0.98	**0.741**
L7	MH	0.74	IV	0.89	1.00	**0.654**
L28-A	MH	0.74	V	0.88	1.00	**0.647**
L29	T5	0.96	V	0.88	1.00	**0.845**
L45	Cold Cathode	0.65	VI	0.87	N/A	**0.562**
L49	CFL	0.85	V	0.88	1.00	**0.748**
L50	CFL	0.85	IV	0.89	1.00	**0.757**

Table 1.10 – Atrium Light Loss Factor Calculations

MODEL CALCULATIONS

Figure 1.11 – Top View Grayscale Luminance Rendering of Atrium

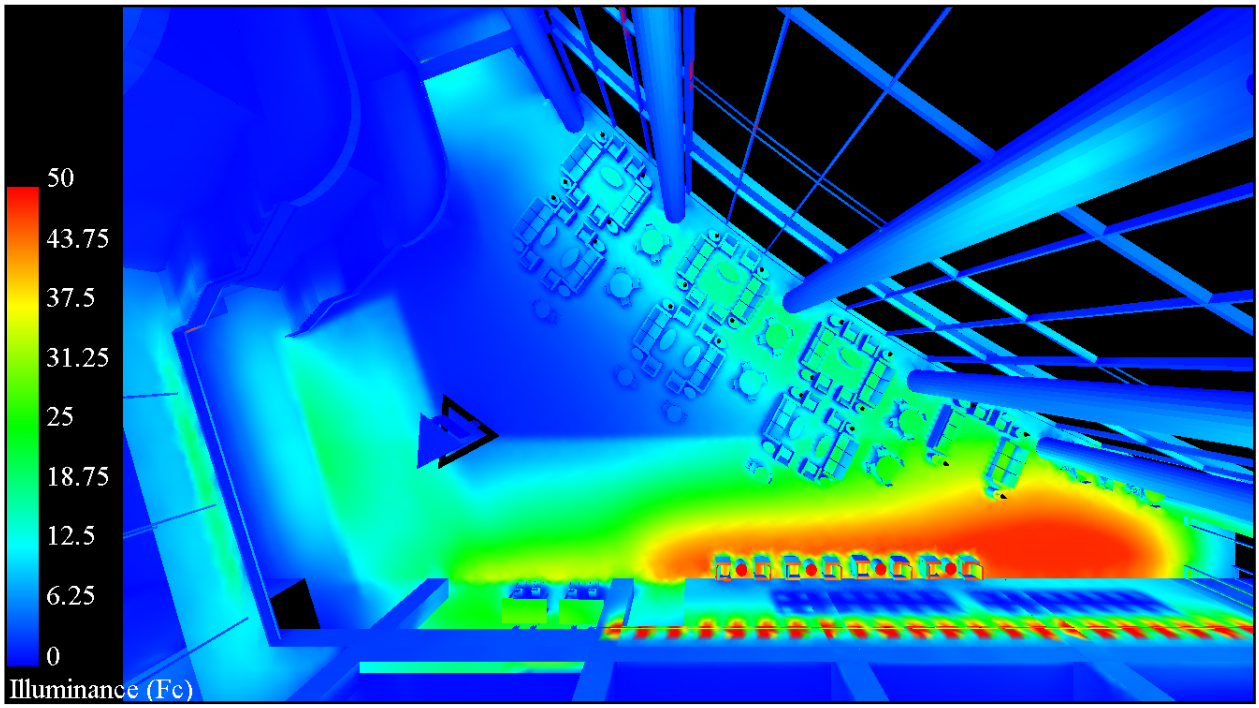


Figure 1.12 – Top View Illuminance Pseudocolor Rendering of Atrium

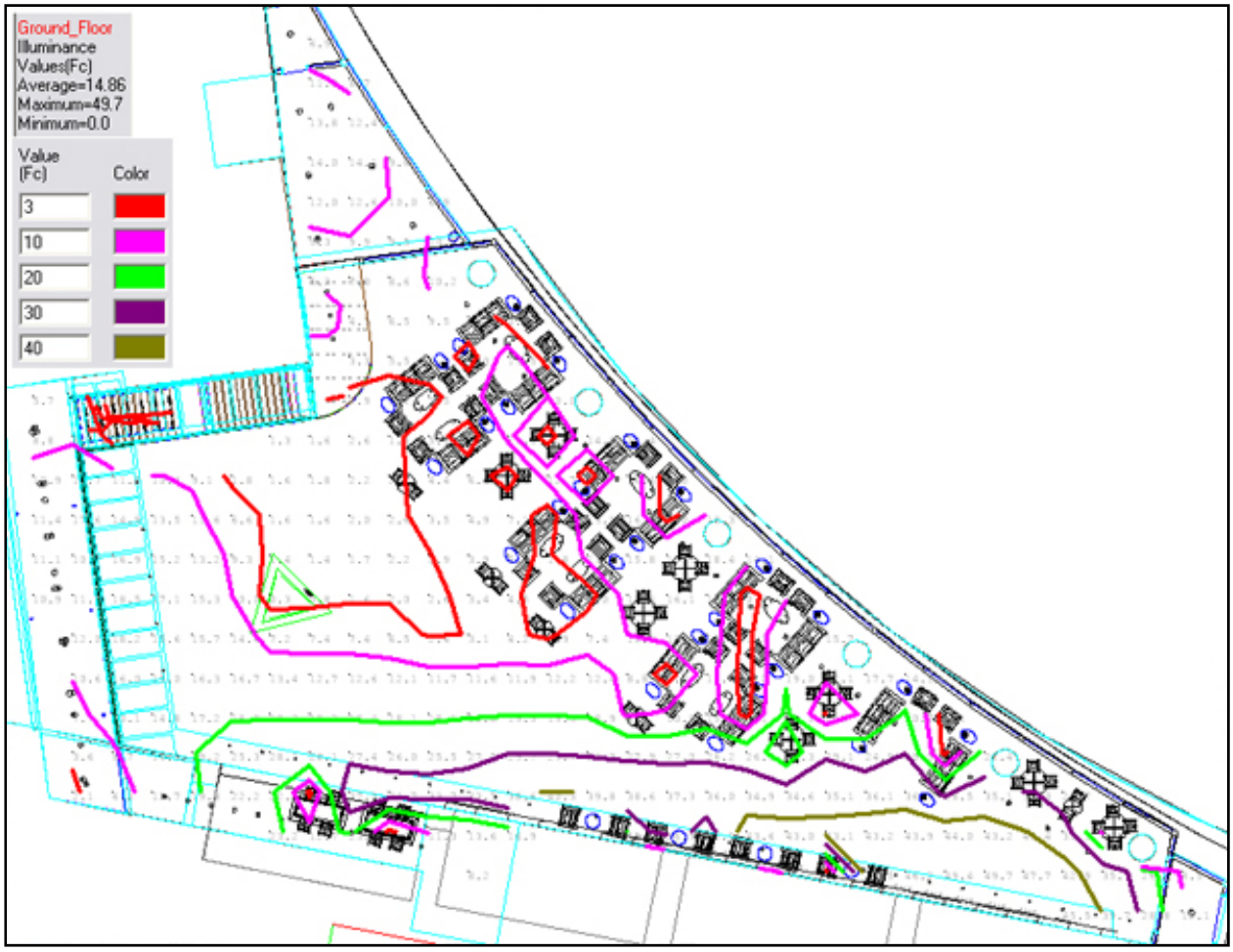


Figure 1.13 – AGI32 Calculation Points of Atrium, Plan View

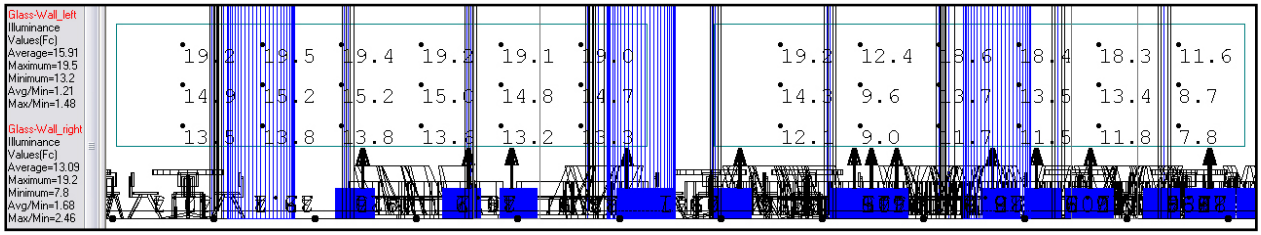


Figure 1.14 – AGI32 Calculation Points of Decorative Glass Wall in Atrium

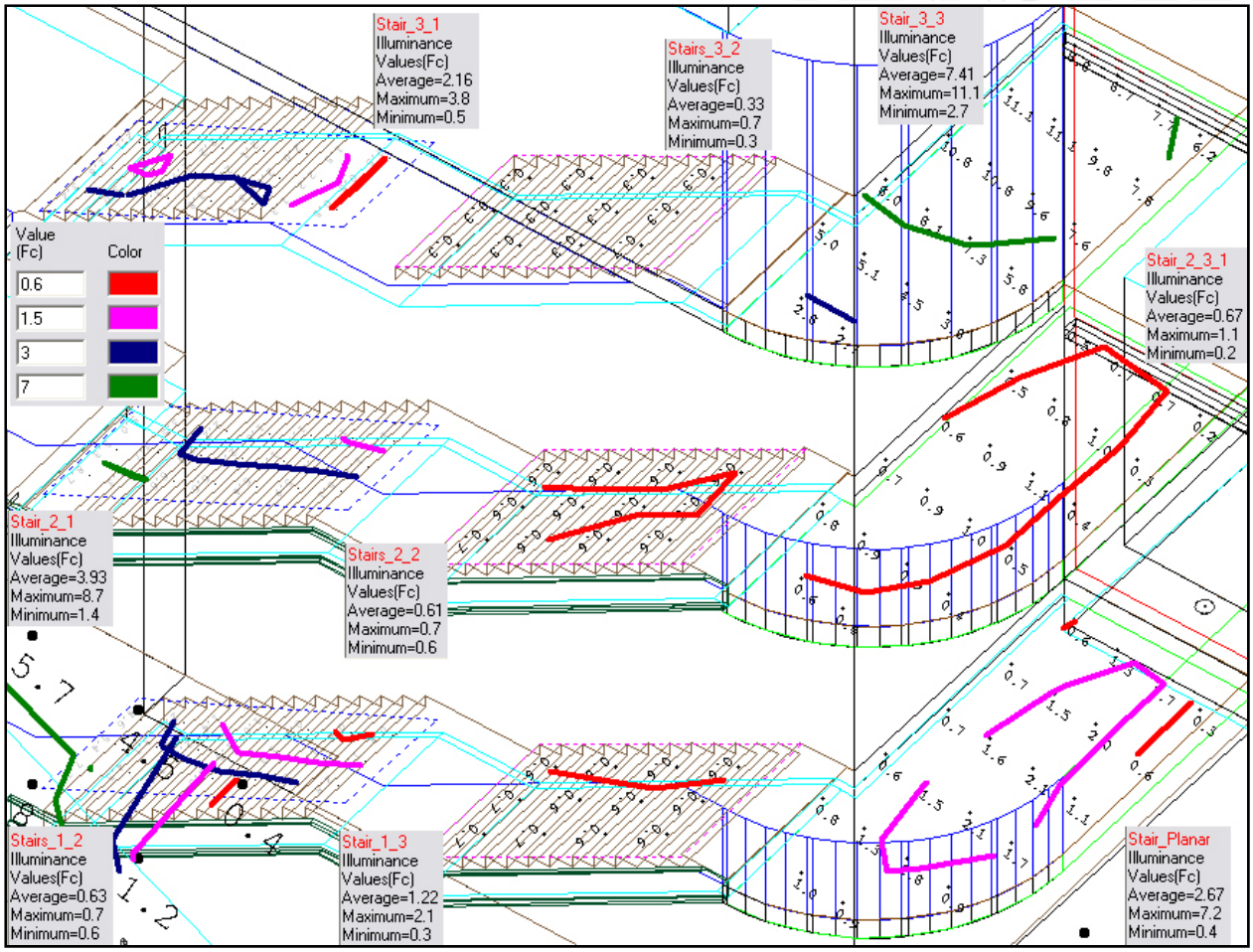


Figure 1.15 – AGI32 Calculation Points on Central Staircase in Atrium

LARGE CLASSROOM

DESIGN CRITERIA

IESNA illuminance recommendations for reading handwritten tasks (both #2 or softer lead pencil and ball-point pen) is 30 hfc, 50 vfc for a chalkboard, and 5 vfc for a whiteboard (or in this case, the two white projection screens). The different vertical illuminance recommendations can be met by providing flexible lighting controls (IESNA's *System Control and Flexibility*).

Since this is a classroom, any design aspects that would help to maximize and encourage a learning atmosphere will be of importance, i.e., comfort is a higher priority than pleasing aesthetics. Of the applicable IESNA design issues, *Direct Glare* and *Flicker (and Strobe)* should be minimized, *Light Distribution on Surface* and *Light Distribution on Task Plane (Uniformity)* should be as even as possible, and fixtures should be laid out carefully to be mindful of *Reflected Glare* and *Source/Task/Eye Geometry*. Facial modeling should also be considered in the podium area for speakers, teachers, and others who would use that space to make presentations.

SPACE PROPERTIES

ROOM

ITEM	MATERIAL/FINISH	ρ
Floor	Carpet, dark gray	0.15
Walls		
General	GWB, painted steel gray	0.45
Curved Back Wall	Perforated Acoustic Wood	0.20
Ceiling		
General	GWB, painted white	0.80
Tile	Acoustic Panel, white	0.70
Doors		
Panel	Wood, natural maple	0.35
Frame (back wall)	Wood, painted white	0.70

Table 2.1 – Classroom: General Room Surface Reflectances

FURNITURE AND OTHER ELEMENTS

ITEM	MATERIAL/FINISH	ρ
Speaker Podium	Wood, natural maple	0.35
Table		
Legs/Supports	Steel, painted black	0.02
Work Surface	Plastic Laminate, white	0.70
Modesty Panel	Plastic Laminate, gray	0.30
Chairs		
Foundation	Plastic, black	0.03
Seat/Back	Upholstery, deep aqua blue	0.19
Visual Display Projection Screen	Fabric	0.90
Chalkboard		
Board	Porcelain Enamel, black	0.02
Frame/Trim/Accessories (e.g. chalk tray)	Aluminum	0.57
Projectors	Plastic, black	0.05

Table 2.2 – Classroom Furniture Reflectances

LIGHTING DESIGN

PLAN

Please refer to Table 2.4 for the classroom luminaire schedule.

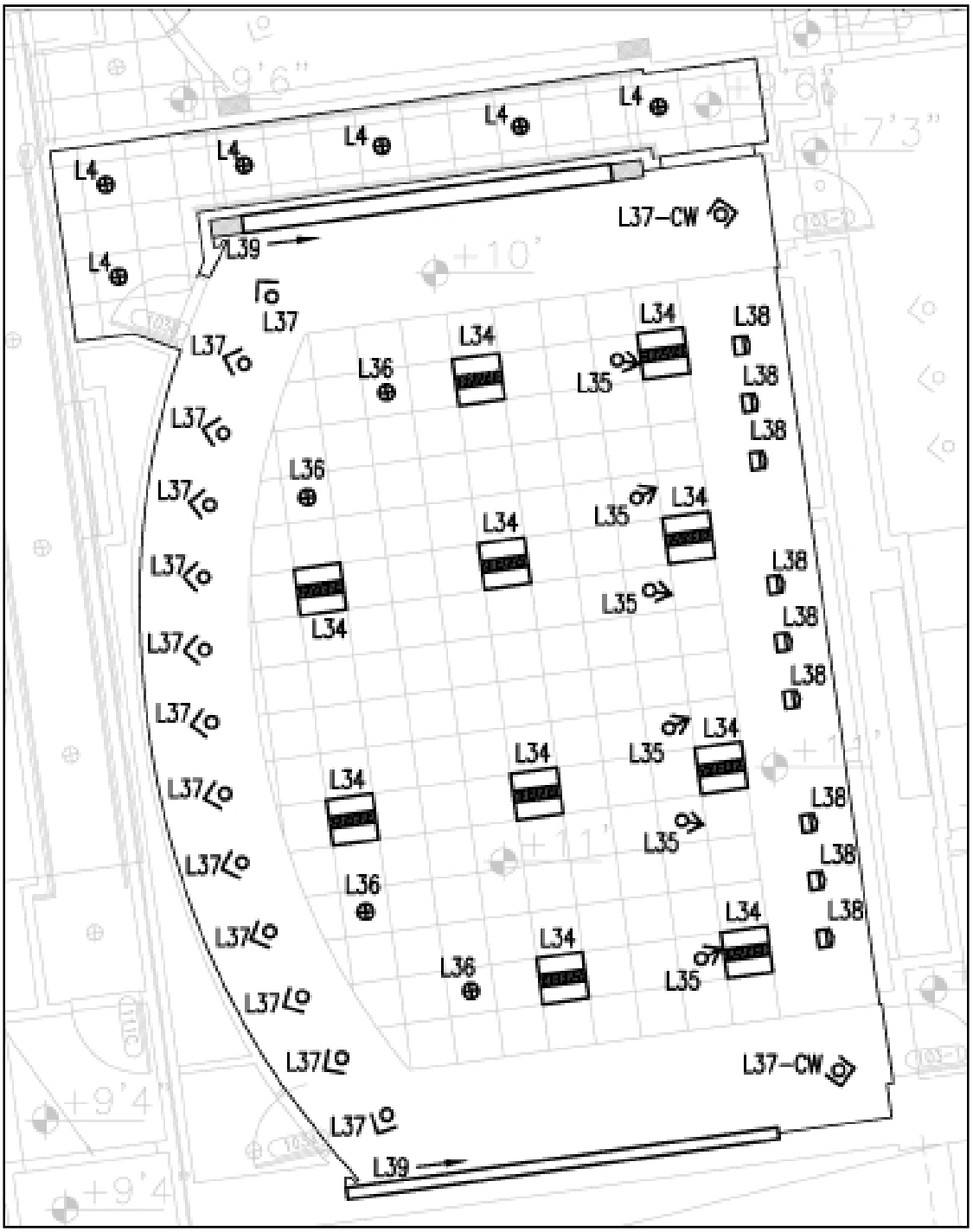


Figure 2.3 – Typical Classroom Lighting Plan

HARDWARE

Table 2.4 – Classroom Luminaire Schedule

SYSTEM PERFORMANCE

POWER DENSITY

DESIGN

Type	QTY	Wattage	Total [W]
L4	6	37 W	222
L34	9	81 W	732
L35	6	100 W	600
L36	4	37 W	150
L37	13	36 W	468
L37-CW	2	36 W	72
L38	9	32 W	288
L39	8	38 W	304
		Total Power	**2,835 W**
		Area	**1,330 ft^2**
		Power Density	**2.13 W/ft^2**

Table 2.5 – Lighting Power Density

ASHRAE/IESNA 90.1

USE	LPD [W/ft^2]
Classroom/Lecture/Training [a]	1.4
TOTAL	**1.4 W/ft^2**

[a] *Table 9.5.1: Lighting Power Densities Using the Space-by-Space Method*

Table 2.6 – Power Allowance for Classrooms

COMPLIANCE CHECK

2.13 W/ft^2 > 1.40 W/ft^2

LIGHT LOSS FACTORS

Type	Lamp	LLD	Maint. Cat.	LDD	RCR	RSDD	BF	TOTAL LLF
L4	CFL	0.85	IV	0.89	13.6	0.94	0.98	**0.697**
L34	CFL	0.85	II	0.95	1.91	0.98	0.95	**0.752**
L35	INCAND	0.91	IV	0.89	1.91	0.98	N/A	**0.794**
L36	CFL	0.85	IV	0.89	1.91	0.98	0.98	**0.727**
L37	CFL	0.85	IV	0.89	1.91	0.98	0.90	**0.667**
L37-CW	CFL	0.85	IV	0.89	1.91	0.98	0.90	**0.667**
L38	CFL	0.85	IV	0.89	1.91	0.98	0.98	**0.727**
L39	T8	0.92	IV	0.89	1.91	0.98	0.85	**0.682**

Table 2.7 – Classroom Lighting Light Loss Factor Calculations

MODEL CALCULATIONS

The classroom has two distinct configuration possibilities: the default configuration has three black chalkboards at the front of the classroom, while the alternate has white visual display projection screens hanging from the ceiling directly in front of the boards. Lighting conditions have been calculated for both configurations as each presents very different surface reflectance characteristics, and an additional calculation was performed for a dimmed lighting condition as well.

CHALKBOARDS

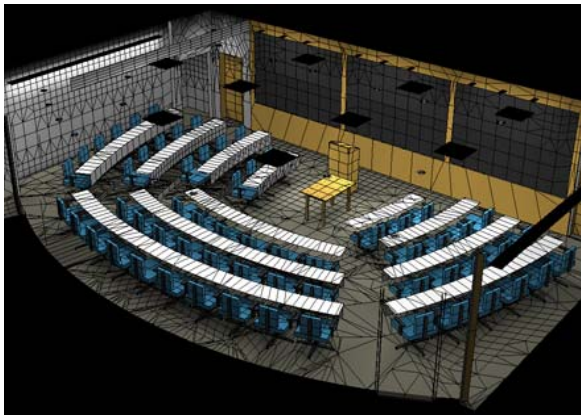


Figure 2.8 – Luminance, Screens Up

PROJECTION SCREENS

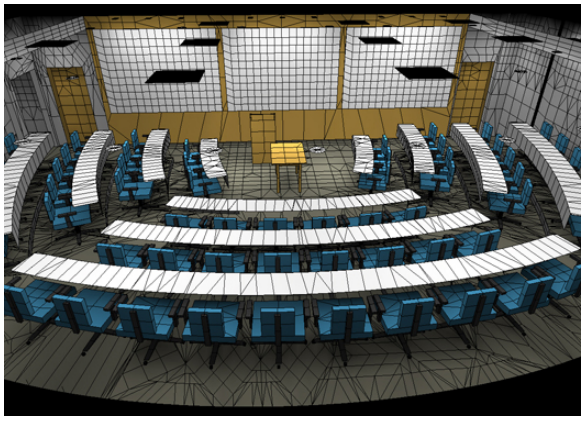


Figure 2.9 – Luminance, Screens Down

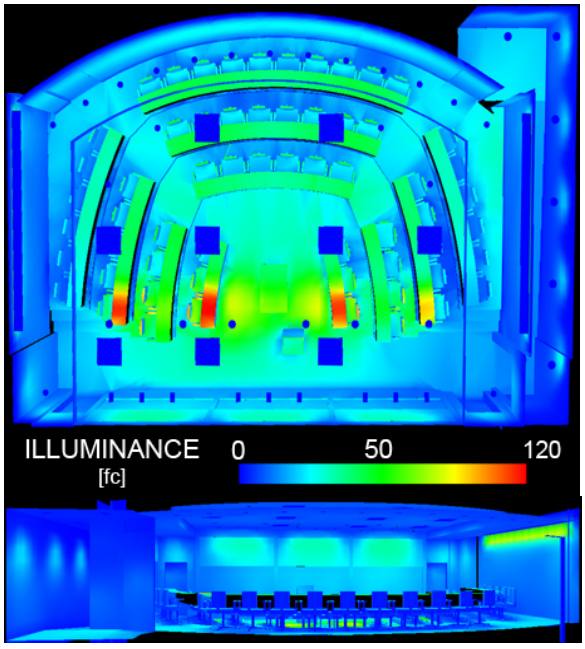


Figure 2.10 – Illuminance, Top and Front Views

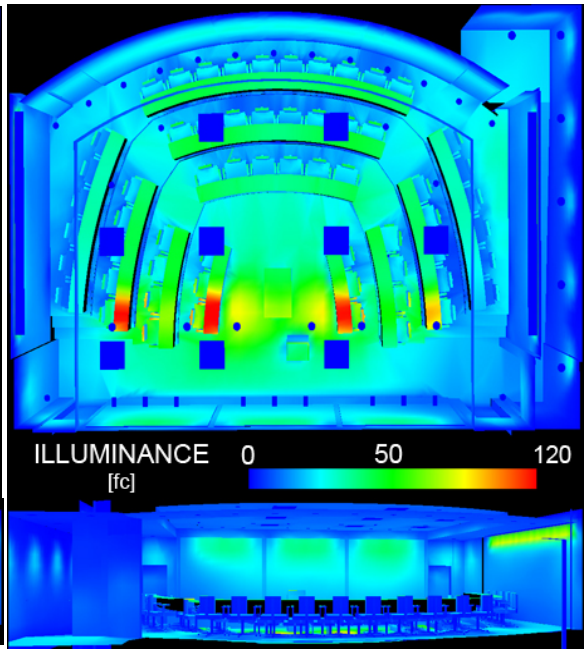


Figure 2.11 – Illuminance, Top and Front Views

CAFÉ

DESIGN CRITERIA

Varieties of tasks are performed in the café, each with different illuminance needs and design issues. Some general tasks include dining, food display, food preparation, and cleaning, and the IESNA recommends certain levels for the cashier areas as well. The following table lists these tasks and their recommended illuminance values and corresponding categories respectively.

TASK	ILLUMINANCE			
	HORIZONTAL		VERTICAL	
Dining	10 fc	C	3 fc	A
Food Display	50 fc	E		
Kitchen				
Counter, general	30 fc	D	5 fc	B
Range	50 fc	E	10 fc	C
Sink	30 fc	D	5 fc	B
Cleaning	10 fc	C		
Cashier	30 fc	D	3 fc	A

Table 3.1 – Café Lighting Design Criteria

SPACE PROPERTIES

GENERAL

ITEM	MATERIAL/FINISH	ρ/τ
Floor	Terrazzo	0.60
Ceiling	GWB, painted white Wood, perforated	0.85 0.30
Walls		
Typical	Wood, natural maple	0.48
Curtain Wall	Aluminum Glass	0.57 0.70
Partitions	Wood, natural maple Decorative Glass	0.48 0.10

Table 3.2 – General Café Surface Reflectances

FURNITURE AND EQUIPMENT

ITEM	MATERIAL/FINISH	ρ
Chairs	Plastic Metal	0.35 0.70
Banquette	Upholstery, multicolored	0.35
Tables	Wood	0.35
Equipment	Stainless Steel	0.44
Countertops	Quartz	0.65
Menu Boards	Paper, laminated	0.65
Cash Registers	Metal	0.44

Table 3.3 – Café Furniture and Equipment Reflectances

LIGHTING DESIGN

PLAN

See Tables 3.5a and 3.5b for the cafe luminaire schedules.

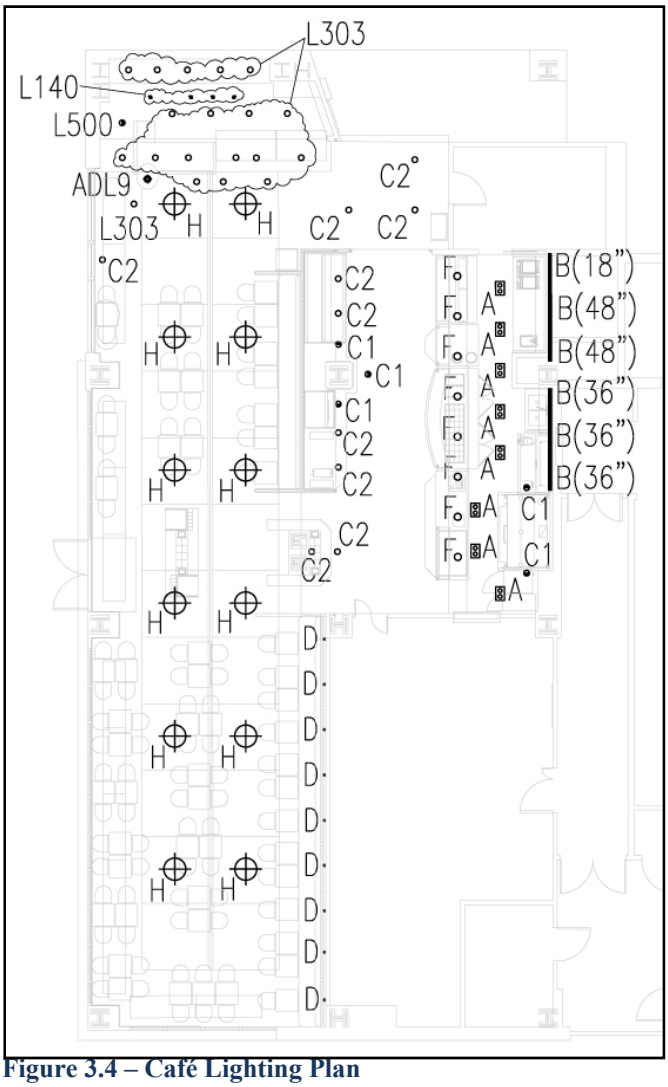


Figure 3.4 – Café Lighting Plan

HARDWARE

SERVERY/SEATING AREA

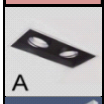
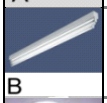
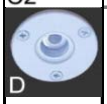
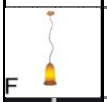
TYPE	DESCRIPTION	MFR/CATALOG #	LAMP	
			W	TYPE
 A	Recessed incandescent multi spot. Fixture Color: white / white step baffle	Juno #MS302-WH **[GE: 14802]*	(2) 75 W	PAR30 HALOGEN, MED. BASE *75PAR30/H/SP10*
 B	Concealed fluorescent staggered fixtures	C.J. Lighting Co. 1000-9 SERIES	48" = 40 W 36" = 30 W 18" = 15 W	T12 WARM WHITE
 C1	Incandescent recessed accent downlight fixture Fixture Color: white	Lightolier #C4P20AWHW-DL8	50 W	PAR20 HALOGEN
 C2	Incandescent recessed downlight fixture Fixture Color: white	Lightolier #C6P30DHW-DL8	75 W	PAR30 HALOGEN, MED. BASE
 D	Fiber optic downlight. Fixture Color: white Illuminator to be water corrosion and chemical resistant.	Super Vision International Downlight #SV-FD703SC, Illuminator #ES-150-42-120 *[#EVO150-42-120],* Endglow Cable #SV-12EG	150 W	Metal Halide
 F	Decorative pendant fixture. Fixture Color: sanded copper, "tobacco" glass shade	Neidhardt Torch Down	60 W	A-19, MED BASE
 H (L33)	Decorative pendant fixture. Fixture Color: white	Louis Poulsen OSP-4-24-W/27W/CF 2G11-120-277V-WHT	(4) 24W	Philips PL-L24W/830

Table 3.5a – Luminaire Schedule for Café's Servery and Seating Areas

COFFEE BAR

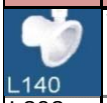
TYPE	DESCRIPTION	MFR/CATALOG #	LAMP	
			W	MFR CATALOG #
 L140	White track fixture on black 8' track	Juno #T220WH *(fixture)* R8BL *(track)*	50	Sylvania 50 PAR 20 CAP/NFL
L303	5" recessed incandescent; shatterproof	Lithonia LPJ *(rough-in)* J01A *(trim)*	75	Sylvania 75 BR30/FL/SL/RP 130V
 L500	6" round fluorescent downlight	Lithonia 18DTT/TRT MVOLT (975962)	18	Sylvania CF18DD/E/827 120V
 ADL9	Pendant, blue	Basic Source #93233	7	Technical Consumer Products Deco Mini Torpedo #10707L120

Table 3.5b – Luminaire Schedule for Coffee Bar Area

SYSTEM PERFORMANCE

POWER DENSITY

DESIGN

Type	QTY	Wattage	Total [W]
A	8	150 W	1,200
B	18"=2 36"=3 48"=2	20 W 40 W 40 W	240
C1	5	52 W	260
C2	9	75 W	675
D	9	205 W	205
F	8	60 W	480
H	12	114 W	1,368
L303	19	75 W	1,425
L500	1	22 W	22
ADL9	1	7 W	7
	Total Power		**5,882 W**
	Area		**2,630 ft^2**
	Power Density		**2.24 W/ft^2**

Table 3.6 – Café Lighting Power Density

ASHRAE/IESNA 90.1

Element	LPD [W/ft^2]
For Bar Lounge/Leisure Dining[a]	1.4
Additional Interior Lighting Power[b]	1.0
TOTAL	**2.4 W/ft^2**

[a] *Table 9.5.1: Lighting Power Densities Using the Space-by-Space Method*

[b] Per *article 9.6.3 (a) for decorative lighting (Type D)*

Table 3.7 – Power Allowance for Café

COMPLIANCE CHECK

2.24 W/ft^2 ≤ 2.40 W/ft^2

LIGHT LOSS FACTORS

Type	Lamp	LLD	Maint. Cat.	LDD	BF	TOTAL LLF
A	HAL	0.97	IV	0.89	N/A	**0.863**
B	T12	0.84	V	0.88	0.92	**0.680**
C1	HAL	0.97	IV	0.89	N/A	**0.863**
C2	HAL	0.97	IV	0.89	N/A	**0.863**
D	MH	0.74	V	0.88	1.00	**0.647**
F	INCAND	0.92	IV	0.89	N/A	**0.819**
H	CFL	0.85	VI	0.86	1.00	**0.731**
L140	HAL	0.97	V	0.88	N/A	**0.854**
L303	INCAND	0.92	IV	0.89	N/A	**0.819**
L500	CFL	0.86	IV	0.89	1.00	**0.765**
ADL9	CFL	0.85	IV	0.89	0.95	**0.719**

Table 3.8 – Café Lighting Light Loss Factor Calculations

MODEL CALCULATIONS

Figure 3.9 – Grayscale Luminance Rendering of Café, Top View

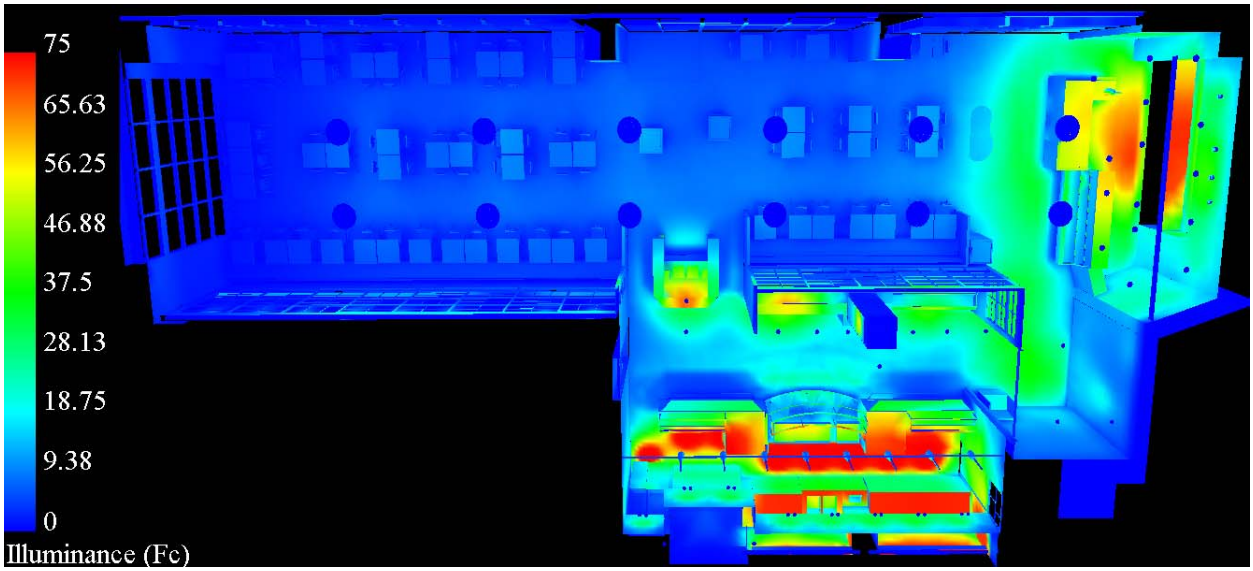


Figure 3.10 – Illuminance Pseudocolor Rendering, Top View

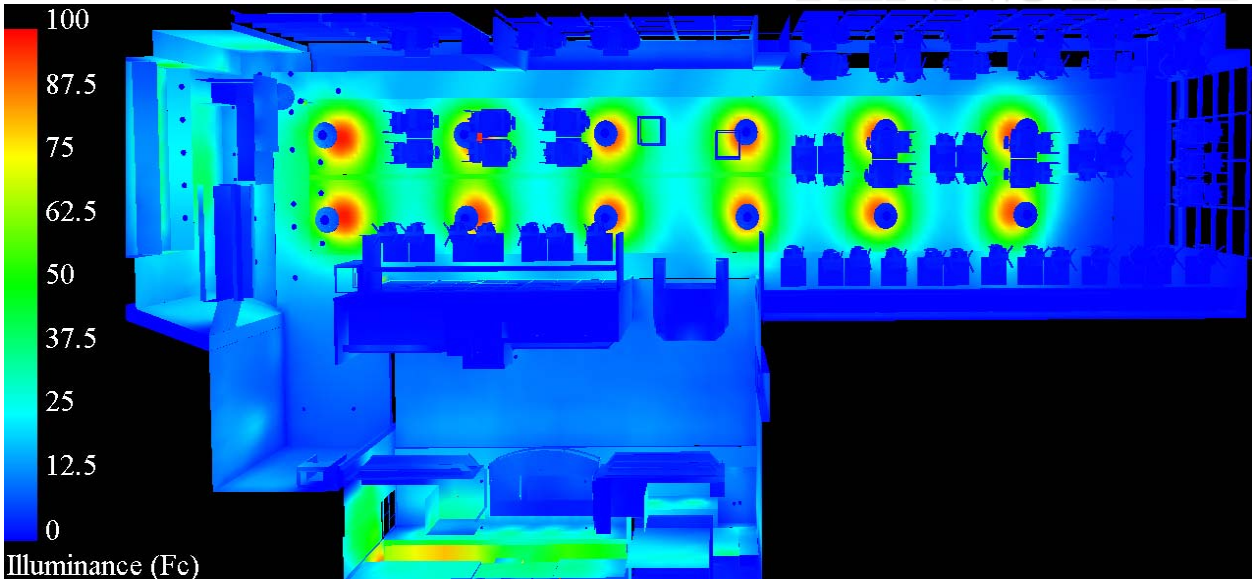


Figure 3.11 – Illuminance Pseudocolor Rendering, Bottom View (Looking At Ceiling)

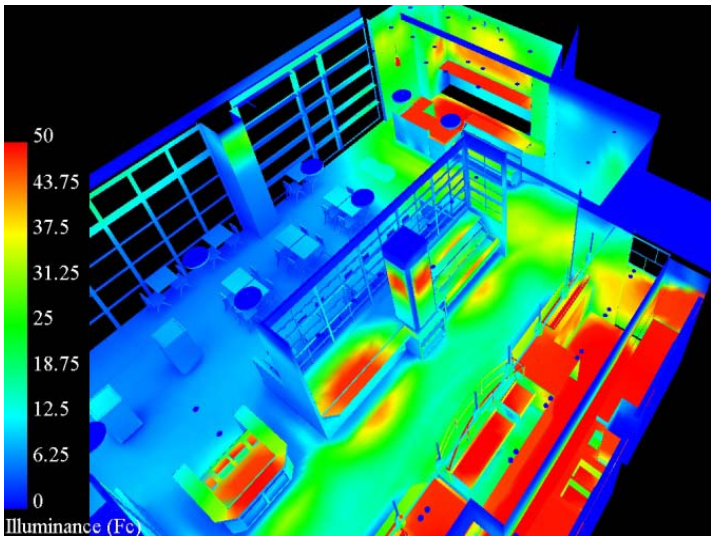


Figure 3.12 – Vertical Illuminances, Southwest View (Looking Towards Coffee Bar)

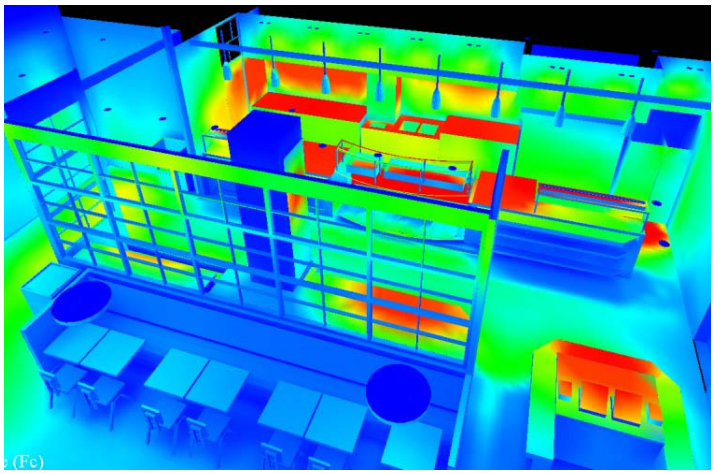


Figure 3.13 – Vertical Illuminances, North View (Looking Towards Servery)

TERRACE

DESIGN CRITERIA

The IESNA Lighting Handbook's illuminance recommendations for an active building entrance and that for a terrace area are both 5 fc for horizontal surfaces and 3 fc for vertical surfaces. A sculpture and some shrubbery exist on the lower level of the terrace but special lighting is not necessary as they are not specially featured elements of the space. *General Appearance of Space and Luminaires* and *Light Pollution* are the most important design issues for this particular space because of its visibility and outdoor location; exterior lighting design must be sensitive to its outer neighbors as well as the immediate space it is lighting because extraneous light will not be contained but could spill out unwelcomed to its surrounding environment instead.

SPACE PROPERTIES

GENERAL

ITEM	MATERIAL/FINISH	ρ/τ
Ground	Brick Limestone	0.33 0.22
Curtain Wall/ Entrance Canopy	Aluminum Glass	0.57 0.70
Typical Wall	Brick Limestone	0.33 0.22

Table 4.1 – General Terrace Surface Reflectances

ELEMENTS

ITEM	MATERIAL/FINISH	ρ
Benches	Metal	0.60
Sculpture	Bronze	0.37
Café Seating		
Chairs	Metal	0.44
Tables	Metal	0.44
Vegetation		
Bed Frame	Concrete, Dirt	0.22
Trees	Bark, etc.	0.40

Table 4.2 – Other Element Reflectances

LIGHTING DESIGN

PLAN

See Table 4.4 for the Terrace Luminaire Schedule.

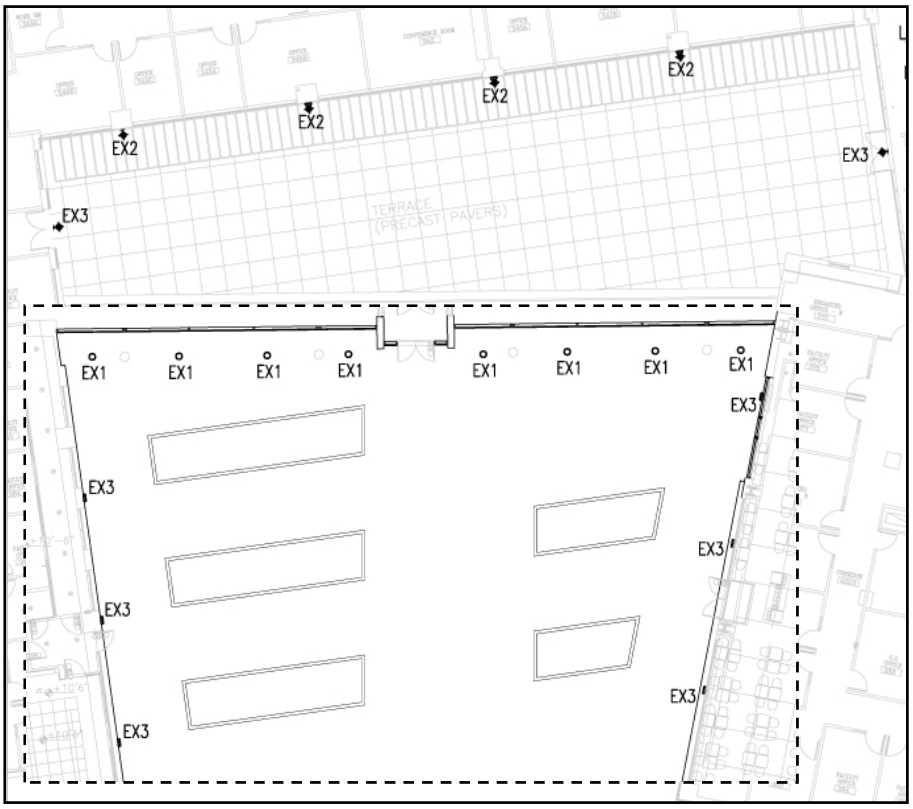


Figure 4.3 – Terrace Lighting Plan, Third Floor (Ground Level Shown in Dashed Box)

HARDWARE

TYPE	DESCRIPTION	MFR/CATALOG #	LAMP	VOLTS
EX1	Recessed-in-ground T6 metal halide adjustable uplight with stainless steel trim ring and integral Aromat electronic ballast. Provide with cast aluminum recessed housing and sculpture lens for 5X55 degree beamspread.	ERCO Tesis Series #33711.023-33953.000-33961.023	Philips T6 39W G8.5	277 V
EX2	Surface mounted metal halide cylinder with integral high power factor magnetic ballast, regressed trim with Solite lens and die cast aluminum construction.	Gardco #300-DW-L-70MH-277-Finish	Sylvania MCP70/U/MED/830	277V
EX3	Surface mounted wall luminaire of die-cast aluminum with fully gasketed tempered clear glass lens and white translucent ceramic coating.	Bega 2295P	Philips PL-L27W/830	277 V

Table 4.4 – Terrace Luminaire Schedule

SYSTEM PERFORMANCE

POWER DENSITY

DESIGN

Type	QTY	Wattage	Total [W]
EX1	8	45 W	360 W
EX2	8	61 W	752 W
EX3	6	30 W	180 W

Table 4.5 – Lighting Power Density

ASHRAE/IESNA 90.1

Element	Power Density	Design Space	Total Power
Canopies[a]	1.25 W/ft^2	690 ft^2	862.5 W
Building Façades[a]	5.0 W/lin. ft.	380 ft	1900 W

[a] *Table 9.4.5: Lighting Power Densities for Building Exteriors*

Table 4.6 – Power Allowance for Exterior Lighting

COMPLIANCE CHECK

Element	ASHRAE	Design	OK?
Canopies	862.5 W	360 W[a]	✔
Building Facades	1900 W	932 W[b]	✔

[a] *Type EX1 only*

[b] *Type EX2 and Type EX 3 only (752 W + 180 W = 932 W)*

Table 4.7 – Power Density Compliance Comparison

LIGHT LOSS FACTORS

Type	Lamp	LLD	Maint. Cat.	LDD	BF	TOTAL LLF
EX1	MH	0.74	VI	0.86	1.00	**0.632**
EX2	MH	0.74	V	0.88	1.00	**0.647**
EX3	CFL	0.85	V	0.88	0.95	**0.711**

Table 4.8 – Terrace Lighting Light Loss Factor Calculations

MODEL CALCULATIONS

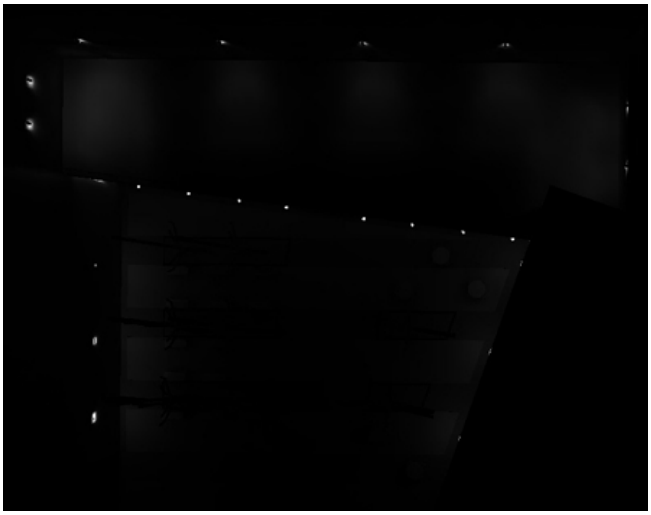


Figure 4.9 – Grayscale Luminance, Top View

Figure 4.10 – Grayscale Luminance, Front View

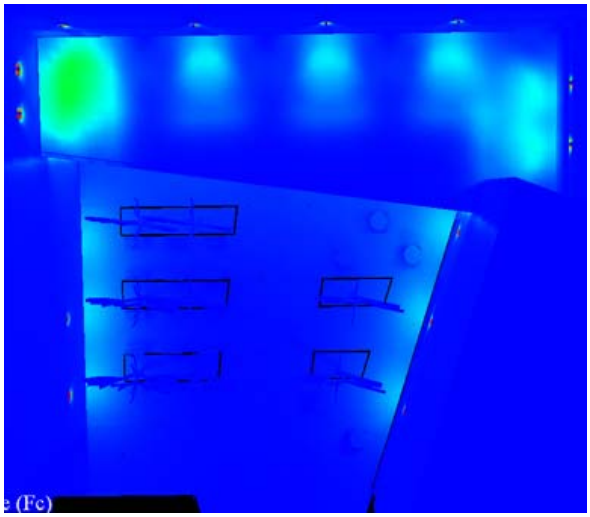


Figure 4.11 – Illuminance, Top View

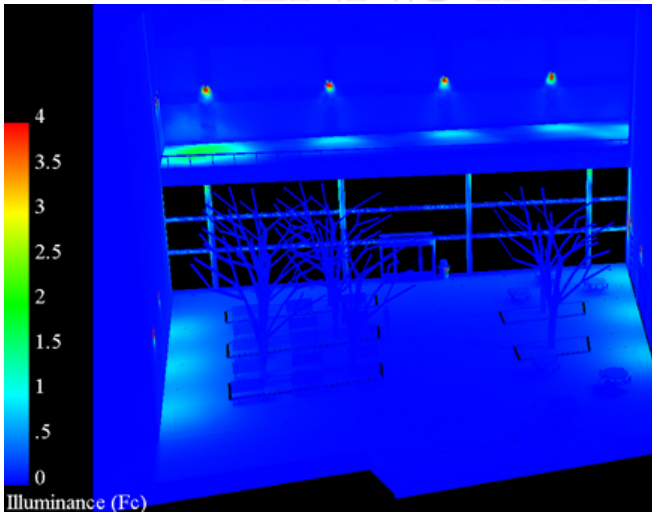


Figure 4.12 – Illuminance, Front View

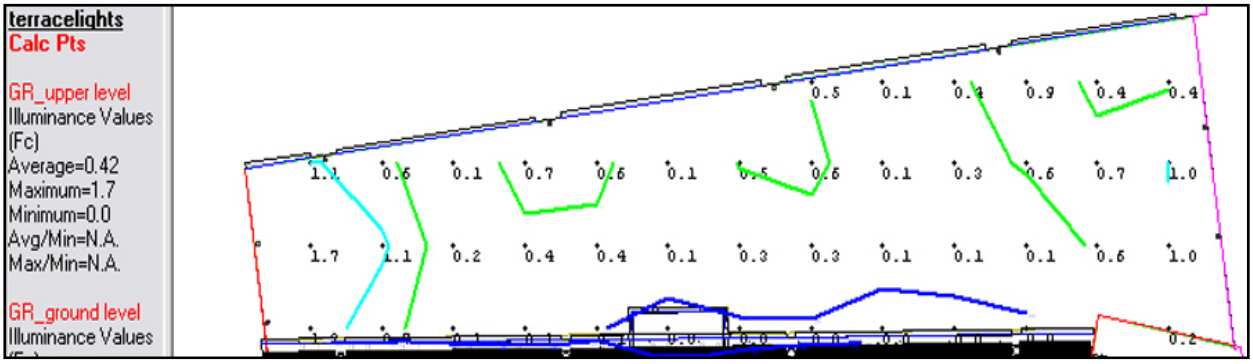


Figure 4.13 – AGI32 Calculation Points, Upper Level (Third Floor)

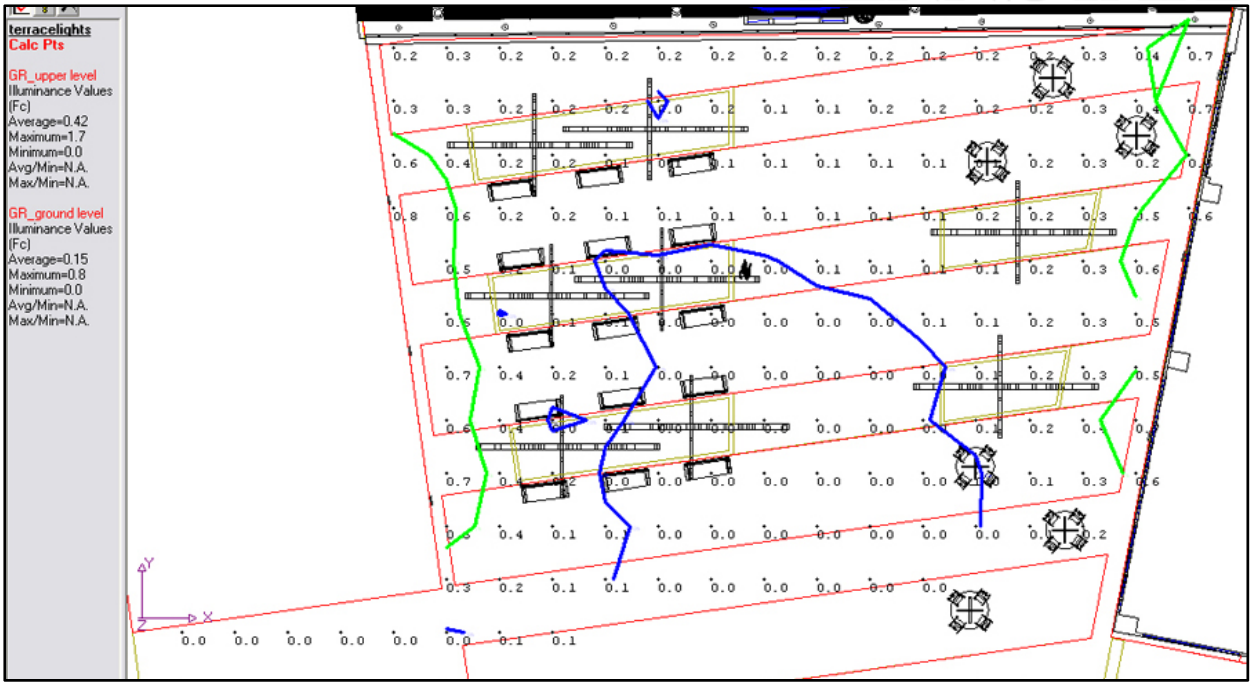


Figure 4.14 – AGI32 Calculation Points, Ground Level